Innovative prosthesis for tracheal collapse resolution

Canine tracheal collapse plays an important role in dogs because of its clinical signs that can lead to respiratory distress and death to those patients. Surgical management is in most cases very challenging because of its costs, difficulties on execution and limited techniques. In order to resolve this common disease we present a series of two cases that show a satisfactory surgical approach to resolve canine tracheal collapse with a new spiral prosthesis that was developed with a biocompatible device that has already been used to mold other prosthesis preconized for treatment and management of other problems such as cardiac valves. **Key-words:** canine tracheal collapse, surgery, dogs.

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**Introduction**

Tracheal collapse is a disease that’s characterized by weakness and flattening of the tracheal rings normally associated with prolapse of the tracheal membrane into the lumen. There are several possibilities for these weaknesses such as congenital or inherited abnormalities. Mostly, those tracheal rings are formed by glycosaminoglycan’s that bind water to the cartilage matrix.\(^1\)\(^,\)\(^2\)

As dogs become older it’s normal to have an increase of the proteoglycan content combined with a decrease of the glycosaminoglycan’s, chondroitin sulfate and cellularity of those rings, contributing for its flaccidity. Those changes can be focused or generalized with association of the main stem bronchi and lower bronchioles, characterizing a case of broncomalacia. Even though clinical signs depend on the severity of the tracheal collapse going from mild airway irritation signs to paroxysmal coughing and dyspnea as a result of dynamic airway collapse\(^1\)\(^,\)\(^3\)\(^,\)\(^4\).

Management of tracheal collapse is mostly done with medicine that reduces tracheal inflammation and diminish cough, which persistence worsens the tracheal inflammation. These medications could include: steroids, strategically used for short periods in order to diminish airway inflammation; antitussive agents; bronchodilators, such as theophylline that may improve mucociliary clearance and reduce diaphragm fatigue; antimicrobial administration only in cases that’s a bacterial infection is proved to be present.\(^2\)\(^,\)\(^3\)\(^,\)\(^5\)

About 71-93% of dogs respond well to treatment for a period over 12 months and some of those can even be gradually withdrawn from medicine management. However some patients, even medicated, still present cough and may present airway distress secondary to pulmonary edema, which is a common complication seen in these patients.\(^1\)\(^,\)\(^3\)

In cases which drug therapy were not succeeded and clinical signs are present, it is important to consider surgical procedures, specially because those patients have an considerable chance to develop airway distress or complications such as laryngeal paralysis. Is known that surgical management of tracheal collapse has been described, used and improved since the 70’s.\(^2\)\(^,\)\(^4\)\(^-\)\(^12\)

There are currently two types of surgical management that include placement of extraluminal stents or intraluminal stents. These last one is less invasive when compared to the extra-luminal technique however other complications have been reported such as fracture and migration of the intraluminal stent and booth complications have a very important role in patients survival\(^2\)\(^,\)\(^5\)\(^,\)\(^12\)-\(^18\).

Surgical management is a great challenge in canine tracheal collapse, especially because there are few techniques described and most of them have some difficulties which can infeasible its application. Therefore use of spiral prosthesis can represent an important alternative for this management.

Based on those information’s the aim of the present work is to report a new device, developed with the support of our research group, used to treat tracheal collapses in dogs with an extraluminal surgical approach. This device is made of a nickel and titanium alloy, also known as nitinol alloy, with a spiral form.\(^9\)
Case description

Two client-owned dogs were referred to our service with a previous diagnostic of tracheal collapse in order to have surgical management. Both patients presented with intermittent cough and cyanosis.

The first patient was a male pug not sterilized and had 8 months by the time of the procedure. Although it was brachycephalic, the patient did not have any other respiratory anomalies besides tracheal collapse. According to owners patient presented a cough with a 9 score in a range from 0 to 10, presented breath difficult and cyanosis.

The second patient was thirteen years old sterilized female pinscher with a heart murmur. The patient presented a cough graded as 10 and was already treated for cardiac disease. Even though there was no improvement in clinical signs after cardiac treatment. Evaluating its pre-operative radiography its possible to observe a left atrial enlargement besides tracheal collapse, better seen through inspiration and across the thoracic inlet, as shown in Figure 1.

![Figure 1](image-url) Lateral radiography views of one patient showing important tracheal collapse across the thoracic inlet during inspiration (A) and a discreet tracheal collapse at the same location during expiration (B). Also note a left atrium enlargement, asterisk, mostly seen during expiration (B).

Both surgeries where performed in dorsal recumbency and the patient where maintained with a stretched neck supported by a pillow. An incision where made through ventral cervical midline from larynx to manubrium, preceded with divulsion of the sternocephalicus and sternohyoides muscles through medium line, always attempting to laryngeal recurrent nerves in order to avoid any damage.

After tracheal identification, two stay sutures were placed around a cranial tracheal ring in order to cranially tract the trachea, surgeon carried on with dissection of the peritracheal tissue in order
to make a tunnel around trachea so the prosthesis could be implanted.

Nitinol spiral prosthesis was inserted exactly around the collapsed trachea, visualization of the prosthesis, after implantation, can be appreciated in Figure 2. Than sternohyoideus muscle, sternocephalicus muscle and skin were routinely closed

Post-operative radiography’s were taken and prosthesis was seen as a radiopaque image around trachea. Post-operative radiography can be seen in Figure 3.

Figure 2 Spiral nitinol prosthesis after implantation in a dog note that prosthesis is around trachea and traction with stay sutures can be cranially made in order to facilitate and improve prosthesis implant.

Figure 3 Post-operative lateral radiography views of the first patient described (A) and second patient described (B) showing nitinol spiral prosthesis as a radiopaque image (arrows).
Patients were followed up by the veterinarians that referred than to our service and owners were phoned interviewed in order to establish patient’s conditions. Questions such as: improvement of cough; respiratory condition; need of medicine to control cough after surgery, other surgical procedures for respiratory signs, diagnose of cardiac problem and grade for the cough before and after surgical procedure. Data related to those answers can be seen in Table 1.

Table 1 Questions asked to pet owners for follow up information after implant of nitinol prothesis.

<table>
<thead>
<tr>
<th></th>
<th>Patient 1</th>
<th>Patient 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does patient still alive?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Had the cough improved?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Respiratory condition.</td>
<td>Better</td>
<td>Better</td>
</tr>
<tr>
<td>Was it necessary any medicine to treat cough</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Has the patient been diagnosed with cardiac disease?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Was any other surgical procedure necessary to treat respiratory problems?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Grade of cough before surgery.</td>
<td>9,0</td>
<td>10,0</td>
</tr>
<tr>
<td>Grade of cough after surgery.</td>
<td>4,0</td>
<td>3,0</td>
</tr>
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Discussion

Post-operative radiography’s shown prosthesis location as a radiopaque spiral image, evaluating those images and comparing than with pre-operative exams was possible to note a considerably improvement of the tracheal collapse. From December 2015 to September 2016 no complications after surgery procedures happened in any of the patients. Contrary to what was observed by some authors we do not have any complications to report yet. However this is limited number of reported cases so studies with more cases are needed.² ³ ⁵ ⁸ ¹¹ ¹⁸.

Clinical signs such as cough and cyanosis can happen when dogs have respiratory diseases or
cardiac diseases\textsuperscript{1-3, 19-26}. The first patient, presented at this case report, was brachiocephalic and its clinical signs could be associated to brachycephalic syndrome however other problems such as elongated soft palate or stenotic nares weren’t present. The second patient had a heart murmur and was already treated for cardiac disease. As seen in pre-operative radiography this patient presented with left atrium enlargement and this could justify clinical signs. However even treated for cardiac disease, cough stood very frequent and we believed that presence of tracheal collapse could be the cause.

Both patients have diminished considerably its clinical signs such as cough, from 50\% to 70\% improvement, and did not present any more cyanosis or respiratory discomfort. Based on clinical improvement and complementary exams findings we concluded that clinical signs associated with tracheal collapse have been solved.

Those findings can be prove that the prosthesis attempt to correct this disease and is a very promising structure to be surgically used, specially because its made by a material that is preconized as good biocompatible product and has been used in a lot of other devices, such as cardiac valves, vena cava filters and orthopedic materials\textsuperscript{12, 14, 27, 28}.

Besides this its form facilitate the implant and the is no need of sutures for fixation contributing to a less inflammation response which avoid other complications such as described for extraluminal polypropylene prosthetic tracheal rings\textsuperscript{29}.

Conclusions

After evaluation of those two cases we concluded that nitinol spiral prosthesis shown to be a satisfactory strategy for surgical management of canine tracheal collapse.

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Conflict of Interest Statements

The authors declare that there is no conflict of interest.

References


